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# Standardization of Postoperative Transitions of Care to the Pediatric Intensive Care Unit Enhances Efficiency and Handover Comprehensiveness

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## Abstract

**Introduction:** To determine the impact of standardization of postoperative transitions of care to the pediatric intensive care unit on handover efficiency and the quality of healthcare data exchange. **Methods:** This was a prospective, pre–post observational study after standardization of postoperative transitions in a 44-bed pediatric intensive care unit in a 313-bed tertiary care pediatric hospital from April to July 2015. Standardization was completed using a multidisciplinary handover checklist. Primary outcomes were efficiency expressed as mean handover duration and the comprehensiveness of healthcare data exchange. **Results:** Forty-seven postoperative transitions were observed of which 23 were preintervention and 24 were postintervention. After standardization, efficiency improved from  $10.5 \pm 5.4$  to  $7.8 \pm 2.7$  minutes ( $P < 0.05$ ). Healthcare data exchanged between surgical, anesthesia, and critical care providers were more robust including intraoperative, historical, and anticipatory guidance (all  $P < 0.05$ ). After intervention, attendance through completion of handover for surgical services increased from 13% to 88% ( $P < 0.05$ ). **Conclusions:** Standardization of postoperative transitions improved efficiency, healthcare data exchange, and anticipatory planning. Future research is required to link standardization of transitions to improved patient outcomes and measure the development of shared mental models.

## INTRODUCTION

Postoperative transitions of care from the operating room (OR) to the pediatric intensive care unit (PICU), defined as the physical and intellectual exchange of healthcare data, knowledge, and accountability between providers, represent critical opportunities for introduction of medical errors.<sup>1</sup> Transitions, commonly referred to as handovers, have been linked to 80% of in-hospital sentinel events and may be

associated with delayed treatment, inappropriate testing, and prolonged hospital length of stay.<sup>2,3</sup> Children undergoing anesthesia and surgery represent a vulnerable population at risk of medical errors after handover from incomplete exchange of pertinent healthcare data, insufficient anticipatory guidance, and lack of a developed, shared mental model.<sup>4</sup>

A successful transition after surgery requires orchestration and teaming between an informed, diverse group of healthcare disciplines including surgical subspecialties, anesthesiology, critical care medicine, nursing, and supportive staff.<sup>4,5</sup> Information exchanged during handover can be complex, necessitating collective attention and integration of multidisciplinary knowledge. Ultimately, transitions result in the development of shared mental models where team members analyze, exchange, and come to mutually understand the patient's disease, surgery, and postoperative plan.

The current pediatric literature is limited but suggests the benefits of structured transitions. For example, after implementation of handover checklist bundles among resident physicians, hospitalized children experienced fewer medical errors and adverse events without disruption of physician workflow.<sup>6,7</sup> After pediatric cardiothoracic surgery, standardization of handover has been shown to improve healthcare data exchange,<sup>8–10</sup> reduce communication errors,<sup>11,12</sup> improve perceptions of handover quality,<sup>11,13,14</sup> and limit adverse events such as unplanned



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extubations.<sup>15</sup> For noncardiac postoperative handover, only 1 study exists where survey data demonstrated improvements in antibiotic and analgesia administration, fewer data reporting errors, and a reduced incidence of hemodynamic or respiratory interventions after standardization.<sup>16</sup> To date, there are no published data to suggest a structured process to improve handover efficiency.

Although organized processes are encouraged in our institution, standard postoperative handover from the OR to the PICU is not mandated. We aim to assess efficiency, discipline-specific data exchange, and team interactions pre-post standardization of postoperative handover.

## METHODS

### *Clinical Setting and Study Design*

Research was conducted within a 44-bed PICU at a 313-bed university-affiliated, tertiary pediatric center. Our institution admits approximately 600 postoperative PICU patients per year. We performed a single-center, prospective pre-post observational study from April to July 2015 in children admitted postoperatively to the PICU. Our institution maintains an independent cardiac ICU, and no data were collected from that unit. As research represented a quality improvement initiative and no protected patient healthcare or demographic data would be collected, it was deemed exempt from direct oversight by our local institutional review board.

### *Intervention Description*

The intervention was standardization of postoperative transitions using a multidisciplinary handover checklist. Checklist items were collaboratively established before study by research team members from anesthesiology, general surgery, critical care medicine, PICU nursing, and pharmacy staff. Disciplines designated as essential to handover had unique checklists that included specific requirements for surgical, anesthesiology, critical care, nursing, and resident providers. Checklists offered discrete expectations of verbal healthcare data exchange, a logical sequence/timeline to handover, and ideal teaming reminders (Fig. 1). As the institution is university affiliated and hosts a variety of trainees, checklists were made easy to follow and did not require previous experience or formal instruction.

### *Outcome Definitions*

Primary outcome measures included efficiency represented as mean handover duration and comprehensiveness of discipline-specific, verbal handover. The start of handover was defined as the initial discussion of patient or operative data by any transition member. Similarly, the end was defined as cessation of discussion between surgical, anesthesia, and critical care providers. Handover comprehensiveness was measured as a percentage of total and individual components including relevant historical, intraoperative, and anticipatory planning data. Provid-

er-specific handover components are listed in Table 1. These components were derived by reviewing the relevant handover literature<sup>1,4,6-16</sup> and collaborative consensus among surgical, anesthesia, nursing, and critical care research team members. A complete handover was defined as an individual participant relaying all healthcare data. Secondary outcomes included indirect measurements of teaming such as the percentage of transitions where nurses were included in decision to begin handover, provider attendance through completion of handover, incidence of prompts for data clarification, and exchange of contact information.

### *Data Collection*

Study observations included all planned postoperative admissions within the defined period who presented from the OR between 9 AM to 5 PM. Observations were not restricted to a specific surgical subspecialty. Transitions were observed by an independent, nonclinical research team member. Checklists were distributed by research staff to all postintervention participants at the time of patient arrival. The study period was divided in half with the first 6 weeks devoted to preintervention data and the last 6 weeks to postintervention. Surgical subspecialties were recorded, but no patient identifying data were collected. All data were stored prospectively in a REDCap® database (Vanderbilt University, Nashville, Tenn.).

### *Statistical Analysis*

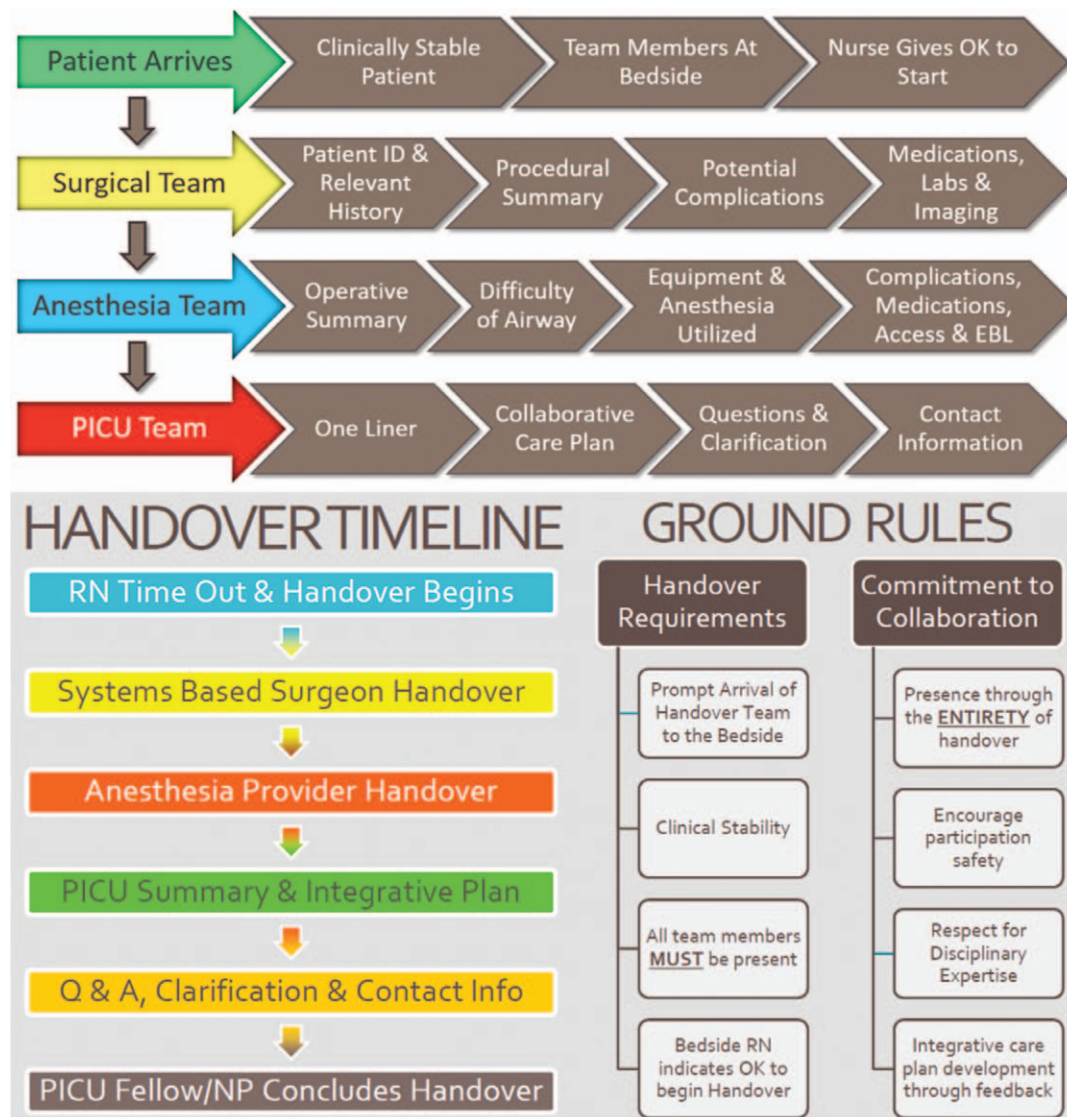
Descriptive data are reported in this manuscript as mean  $\pm$  SD or median (interquartile range) depending on data variance. Student's *t* test and Wilcoxon signed-rank sum test were used for continuous variables. Fisher's exact test was used for categorical variables. For all tests, the level of significance was set at *P* value less than 0.05. Statistical analyses were completed using Stata® version 13.1 software (Stata, College Station, Tex.).

## RESULTS

Forty-seven postoperative transitions to the PICU were observed of which 23 were preintervention and 24 postintervention. When compared to the preintervention cohort, the postintervention cohort carried more neurosurgical cases (16 vs 8; *P* < 0.05) and fewer otolaryngeal cases (2 vs 9; *P* < 0.05). The remaining caseloads were well matched including general (5 vs 3), orthopedic (3 vs 2), and plastic (2 vs 3) surgical cases.

The mean duration of handover pre intervention was  $10.5 \pm 5.4$  minutes. After standardized handover, duration was reduced to  $7.8 \pm 2.7$  minutes (*P* < 0.05). Total and individual handover content including patient identification, relevant historical, intraoperative procedural, and anticipatory planning data were more comprehensive after standardization of handover (Table 1).

Attendance at initiation of handover improved for both surgical providers (52% vs 83%; *P* < 0.05) and PICU



**Fig. 1.** A collaboratively developed, multidisciplinary conceptual model of healthcare data exchange, event sequence, and optimal teaming cues for postoperative transitions of care.

**Table 1.** Discipline-specific, Postoperative Handover Components Pre and Post Standardization

| Handover Components, n (%)         | Preintervention, n = 23 | Postintervention, n = 24 | P     |
|------------------------------------|-------------------------|--------------------------|-------|
| Surgical providers                 |                         |                          |       |
| Past medical history               | 10 (43.5)               | 22 (91.7)                | <0.05 |
| Procedure description              | 13 (56.5)               | 22 (91.7)                | <0.05 |
| Operative complications            | 10 (43.5)               | 22 (91.7)                | <0.05 |
| Anticipatory guidance              | 13 (56.5)               | 22 (91.7)                | <0.05 |
| Requested imaging or labs          | 11 (47.8)               | 21 (87.5)                | <0.05 |
| Anesthesia providers               |                         |                          |       |
| Assessment of airway               | 15 (65.2)               | 21 (95.8)                | <0.05 |
| Endotracheal tube size and depth   | 13 (56.5)               | 16 (66.7)                | 0.56  |
| Induction/sedation used and timing | 17 (73.9)               | 23 (95.8)                | <0.05 |
| Other medications used and timing  | 16 (69.6)               | 23 (95.8)                | <0.05 |
| Estimated blood loss               | 15 (65.2)               | 20 (83.3)                | 0.19  |
| Operative complications            | 15 (65.2)               | 22 (91.7)                | <0.05 |
| Vascular access type and location  | 17 (73.9)               | 23 (95.8)                | <0.05 |
| Critical care providers            |                         |                          |       |
| Patient historical summary         | 13 (56.5)               | 23 (95.8)                | <0.05 |
| Reviews procedure performed        | 14 (60.9)               | 23 (95.8)                | <0.05 |
| Reviews any complications          | 14 (60.9)               | 22 (91.7)                | <0.05 |
| Postoperative plan reviewed        | 17 (73.9)               | 23 (95.8)                | <0.05 |
| Need for labs                      | 8 (34.8)                | 22 (91.7)                | <0.05 |
| Need for imaging                   | 9 (39.1)                | 17 (70.8)                | <0.05 |



Table 2. Pre- and Postintervention Duration of Handover and Provider Attendance Data

| Variable   | Preintervention | Postintervention | P     |
|--|-----------------|------------------|-------|
| Duration of handover, min                                | 10.5±5.4        | 7.8±2.7          | <0.05 |
| Attendance at initiation of handover, n (%)              |                 |                  |       |
| Surgical provider  | 13 (56.5)       | 22 (91.7)        | <0.05 |
| Anesthesia provider                                      | 19 (82.6)       | 22 (91.7)        | 0.42  |
| Critical care LIP  | 23 (100)        | 23 (95.8)        | >0.99 |
| Critical care resident                                   | 12 (52.2)       | 20 (83.3)        | <0.05 |
| Attendance at completion of handover, n (%) <sup>*</sup> |                 |                  |       |
| Surgical provider  | 3 (13)          | 21 (87.5)        | <0.05 |
| Anesthesia provider                                      | 18 (78.3)       | 22 (91.7)        | 0.25  |

<sup>\*</sup>The attendance through the completion of handover is critical as the reader will note a significant improvement in attendance through the completion of handover after standardization.

LIP, licensed independent practitioner.

residents (57% vs 92%;  $P < 0.05$ ) after standardization. In the preintervention cohort, attendance through completion of handover was low for all but PICU providers (Table 2). After intervention, attendance upon completion of handover had increased for surgical providers from 13% to 88% ( $P < 0.05$ ).

The frequency of prompts for data clarification and questions increased from 70% to 90% ( $P < 0.05$ ) after intervention. In most observations (83%), providers respectfully waited for a verbal signal from bedside nursing that the patient was clinically stable and nursing was available to actively participate in handover. Although we were not able to detect a difference, the proportion of transitions where contact information between providers and bedside nursing was exchanged rose from 43.5% to 70.8% ( $P = 0.08$ ).

## DISCUSSION

In this prospective, pre–post observational study, standardization of postoperative transitions with a multidisciplinary handover checklist considerably improved the overall content of data communicated between team members. Simultaneously, we observed enhanced efficiency with an absolute reduction of mean handover duration by 2.7 minutes (a 26% improvement). These findings emphasize the utility of standardization in transition processes. A culture of safety is founded by a recognition among members of a working unit that errors occur as a matter of human nature and that accepting lower standards as a result of inescapable errors is unsatisfactory.<sup>17</sup> This conceptualization gives rise to high-reliability organizations and drives quality improvement processes such as those described in this study.

Mohorek and Webb<sup>18</sup> published a conceptual framework for handover borrowing from cognitive communication theory as the potential etiology for medical errors in transition. Their model depicts transmission of data from the primary source, in the study scenario the surgeon and anesthesiologist, to its destination, the PICU providers, bedside nursing, and staff. Disruption at any point along the communication continuum, be it during transmission, encoding, decoding, or processing of information, leads to cognitive deficits and potential errors. Ironically, efforts to improve safety outcomes with mandates such as work

hour restrictions have resulted in the increased number of provider transitions.<sup>17</sup> PICU providers and nurses have increasingly competing responsibilities during transitions such as the transfer of technology and equipment, physiologic monitoring, mechanical ventilation, medication administration, and the care of other critically ill children.<sup>5</sup> Our data suggest that standardization with a checklist optimizes handover data. This resonates with published findings in handover communication bundles, mitigating errors in diagnosis, selection of suitable postoperative therapies, and anticipatory planning.<sup>6–16</sup>

Prospective determinants of operative teaming include active participation, diversity, leadership style, supportive infrastructure, shared goal development, and interdependence.<sup>19,20</sup> As secondary outcomes, we indirectly measured elements of collaboration and disciplinary interdependence. Our findings regarding interactions between providers and nursing, prompts for data clarification, exchange of contact information, and attendance through the completion of handover suggest that standardization of transition processes with a checklist may be used to optimize teaming. This study did not directly assess for causality for improved attendance by surgical providers, but we suspect that these findings were at least partially the result of improved perception of handover quality, value, and efficiency.

## Study Limitations

Our study was conducted in a single center, and we can only speculate to its generalizability to other institutions. We did not directly measure the development of a shared mental model after handover or relevant health-care outcomes, such as the incidence of preventable errors or appropriateness of postoperative care. As a clear timeout was not designated pre intervention, it is possible that unclear start and finish times existed and resulted in observed differences in handover efficiency. Participant attention was not directly including the incidence of interruptions or parallel discussions during handover. Attention is critical to effective information exchange and should be more thoroughly studied in the future. Provider behavior and experience with handover were not evaluated, and we cannot determine if experience biased behaviors during handover. Although study timing did fall in the transition between 2 academic years, we do not

believe that this had any impact on participant behavior or study outcomes. Although the procedure caseloads were generally well matched between pre- and postintervention cohorts, no formal matching was performed. Subtle differences in patient or procedural complexity could explain differences observed in handover duration. Controlling for these variables by matching may prove useful in future handover investigation. Finally, where preintervention handover participants were unaware of clinical investigation, the study design unavoidably alerted the postintervention participants to research activities and may have led to bias.

## CONCLUDING SUMMARY

Implementing a standardized handover checklist for OR to PICU transitions allowed for exceptional handovers with robust data exchange and improved efficiency. Our secondary findings suggest that standardization of handover resulted in improved attendance and indirectly collaboration and interdependence between providers. Given these findings, we recommend standardization of transition processes in critically ill children. Further study is required to link standardization to clinical outcomes such as reductions in adverse events, medical errors, and the development of a collective mental model.

## DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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